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OATS:
GROWING THE CROP.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., September 21, 1910.

SIR: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript on "Oats: Growing the Crop," prepared by Mr. C. W. Warburton, Agronomist in Charge of Oat Investigations, under the direction of Mr. M. A. Carleton, Cerealist in Charge of Grain Investigations.

With the single exception of wheat, oats is the most important small-grain crop in this country. In general, however, our climatic conditions are not favorable to the production of this crop, while the methods of growing it do not produce the best results in yield or quality. This bulletin gives the best available information on the proper methods of growing and harvesting oats. The publications of the state agricultural experiment stations have been freely used in its preparation, and experimental data are presented to substantiate most of the statements made.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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NOTE.—A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.

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OATS: GROWING THE CROP.

INTRODUCTION.

Oats is one of the most important grain crops in the North Temperate Zone. In the United States this crop is exceeded in area and value only by corn and wheat, while in Canada it is even more generally grown than in the United States. In Great Britain and Ireland the acreage devoted to oats is little less than that devoted to all other grain crops. In Germany it exceeds the combined acreage of wheat and barley and is second only to rye. In all the countries of northern Europe the oat crop occupies an important place. In spite of its importance, no other grain crop in the United States is handled so carelessly, particularly in the States where the crop is most largely grown; there is little wonder, therefore, that the yields secured are often unsatisfactory and the crop sometimes unprofitable. The aim of this bulletin is to outline the best methods of producing oats, as demonstrated by the work of the agricultural experiment stations and practiced by good farmers. The utilization of the crop is discussed in Farmers' Bulletin 420, entitled "Oats: Distribution and Uses."

ORIGIN AND HISTORY OF OATS.

The original wild form of the cultivated oat is not definitely known, although it is believed to have existed in western Asia and eastern Europe. The records do not show that this crop was known to the early Egyptians, Greeks, or Romans, as were wheat and barley. It is probable that oats were first cultivated in northern and central Europe, in what is now Austria-Hungary and Russia. Like several of our other cultivated plants, this grain was carried westward from its place of origin in western Asia and eastern Europe by the migration of the inhabitants of that region early in the Christian era. It is probable that oats were first used for feeding animals and that their use as human food was confined to times when other grain or food was scarce. Its general use as food for man is evidently of recent origin and is due to the development of milling machinery. Naturally the people of early times used as food those grains which could be prepared most easily. For this reason wheat and rye, which thrash clean, were used instead of oats, which remain inclosed in the hull.

Our cultivated varieties are generally believed to have been developed from *Avena sativa*, though some botanists claim that *Avena fatua*, the common wild oat, or *Avena strigosa*, one of the European wild oats, was the parent species. Others assert that the oats commonly grown in our Southern States and in southern Europe were developed from *Avena sterilis*, the wild oat of northern Africa. The side or eastern oat and the naked or hull-less oat, though now widely different in form from the common or panicled type, are believed to have had the same origin, and all are usually classed as varietal forms of *Avena sativa*.

DESCRIPTION OF THE OAT PLANT.

The oat, like most of our other grains, is classed by botanists among the grasses, or Gramineae. It belongs to the genus Avena, which includes in addition to the cultivated oat, *Avena sativa*, a number of wild species, like *Avena fatua*, the common wild oat, which are troublesome weeds. None of the closely related plants are of much economic importance, though tall oat-grass and velvet grass are grown to some extent as forage grasses.

The oat plant produces several jointed, hollow stems, or culms, 2 to 5 feet in height, averaging about 3½ feet. The roots are small and fibrous, but penetrate the soil to a depth of 3 or 4 feet. The leaves are rather broader and more numerous than those of wheat. The panicles, or heads, as they are commonly called, are usually open, or spreading, but occasionally the branches of the panicle are much shortened and turned to one side, producing the type known as side, or horse-mane, oats. The grain is borne on small branches of the panicle, in spikelets, which vary in number from 25 to 100 or more. Usually these spikelets contain two grains, though in some varieties several are produced. The spikelet is loosely inclosed within the outer glumes, or chaff, which, with the culms, or straw, become light yellow at maturity. The individual grains are usually tightly inclosed in the flowering glumes or hull, though in the form known as hull-less oats the flowering glumes are easily removed. The hull varies in color with the different varieties, the most common colors being white, yellow, reddish-brown, and black. The kernel is rather more slender than that of wheat, usually much softer, and is thickly covered with fine hairs; it ordinarily makes up two-thirds to three-fourths of the weight of the whole grain.

SOILS ADAPTED TO THE PRODUCTION OF OATS.

TYPES OF SOIL.

In the production of oats proper climatic and cultural conditions are of more importance than the character or even the fertility of the soil. Owing to their greater water-holding capacity loam and clay

soils usually produce better crops than sandy soils. Sandy land with plenty of plant food and a moderately stiff subsoil will grow good oats, but heavy, undrained clays are too wet and cold for the best growth of the crop. More water is required to produce a pound of dry matter in oats than in any other cereal, hence the necessity for growing this crop on land which naturally retains moisture or which is well filled with humus. On account of their liability to lodge, oats should not be grown on very rich soil or on low, undrained lands. Good drainage is essential also in the prevention of injury from plant diseases.

FERTILIZERS AND MANURES.

The quantities of the three important fertilizing elements removed by a crop of grain vary somewhat in different portions of the country, as they depend on the yield of the individual crop and the proportion of grain to straw. For this reason no general estimate of the fertilizer removed by an acre of oats can be given. According to Chilcott[a] under South Dakota conditions a 45-bushel crop of oats removed from the soil approximately 44 pounds of nitrogen, 16 pounds of phosphoric acid, and 37 pounds of potash. A 30-bushel crop of corn removed a little more phosphoric acid and potash and about one-third more nitrogen than the oats, while a 40-bushel crop of barley removed considerably more of all three of these fertilizing elements. A 15-bushel crop of wheat removed but 35 pounds of nitrogen, 9 pounds of phosphoric acid, and 15 pounds of potash. These figures show that nearly as much fertility is required to produce a good crop of oats as of any other grain, so that the common practice of using the poorest land on the farm for growing oats is not to be commended. While the oat crop is a vigorous feeder and will do better on poor soils than will most other grain crops, yet the judicious use of fertilizers or manure is usually profitable. The fertilizer problem is made difficult, however, by the fact that on rich soil oats make a rank growth, which often results in lodging and in conditions favorable to rust and other diseases.

Unless the soil is very low in fertility the direct application of barnyard manure to the crop is seldom advisable. Much more satisfactory results can usually be secured by applying the manure previous to growing some other crop in the rotation, such as corn. The oats will then get the benefit of a part of the manure and of the added humus in the soil, with less danger that a rank growth of straw will be made at the expense of grain production. On very poor soil the application of a few loads of well-rotted manure some time previous to sowing oats can be made to advantage. The manure should be applied as evenly as possible and should be well worked

[a] Bulletin 79, South Dakota Agricultural Experiment Station.

into the soil. Under these conditions the use of a small quantity of raw rock phosphate with the manure is usually advisable.

Of the three fertilizing elements nitrogen, phosphorus, and potash, phosphorus is most often the one which is not present in sufficient quantities for the best production of oats. This is particularly true of certain types of prairie soils of the upper Mississippi Valley, where a large portion of the oat crop is grown. In a 2-year rotation of corn and oats at the Illinois station in which 200 pounds of bone meal, containing 25 pounds of phosphorus, was applied annually, the average gain in yield of oats in six years was 12.2 bushels to the acre. This was on the plats in which a legume was grown in the corn and which were limed before the experiment was begun. The use of phosphorus without the legume was less profitable, while the addition of potassium to the plats which were fertilized with phosphorus resulted in a lessened yield of both corn and oats. Similar results were obtained in a 3-year rotation of corn, oats, and clover.

The Ohio station is conducting a fertilizer test at Wooster and at Strongsville on a 5-year rotation of corn, oats, wheat, and two years of hay crops. Professor Thorne [a] says of this experiment:

> The highest net profit, considering the oat crop alone, is found in a 13-year test at Wooster on the plat receiving a complete fertilizer relatively low in nitrogen and high in phosphorus; the plat receiving phosphorus only coming next and closely followed by that receiving both phosphorus and potassium. In ten years' results at Strongsville, the only decided profit is found on the plat receiving phosphorus only, although the increase has more than paid for the cost of the fertilizer on the plats receiving phosphorus and nitrogen, phosphorus and potassium, and phosphorus, potassium, and a small amount of nitrogen.

The greatest net profit for the entire rotation for ten years at Wooster was from the plat receiving the complete fertilizer, while that receiving phosphorus and nitrogen returned a slightly smaller profit. At Strongsville by far the largest gain was from the plat receiving phosphorus only; the plat receiving phosphorus and potassium ranked second in net gain.

The experiments just cited, and others which might be mentioned, show that phosphorus is usually the most important addition which can be made to the soil for the production of oats, but small quantities of nitrogenous fertilizer can often be used to advantage. The oat crop makes most of its growth early in the season, when the weather is cool and before much of the nitrogen in the soil becomes available for plant food. For this reason the application of a small quantity of nitrogen in a readily available form, as nitrate of soda, will hasten its growth and result in materially increased yields.

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[a] Bulletin 182, Ohio Agricultural Experiment Station.

Potash can usually be added to better advantage when applied to some other crop in the rotation, as corn or wheat. This element of fertility is usually present in large quantities in clay soils, but is often a valuable addition to sandy or gravelly ones. The loss from the application of potassium in the Illinois experiments just cited was probably due to an excess of that element in the soil, while in the Ohio tests the quantity applied was much larger than would ordinarily be used by the farmer. The application of 10 to 20 pounds of actual potash to the acre annually is usually sufficient on loam and clay soils, but on soils that are known to be exceptionally rich in this material its use is unnecessary.

A good fertilizer for oats on the heavier loam and clay soils is one containing 50 pounds of nitrate of soda and 150 pounds of acid phosphate, applied at the rate of 200 pounds to the acre. On sandy and gravelly soils the addition of 20 to 40 pounds of muriate of potash to this combination is usually beneficial. The exact quantity to be applied and the proportion of the different fertilizing elements depend largely on the nature and the fertility of the soil. The straw of grain crops may be strengthened by the use of fertilizers containing potash and phosphorus, and in this way lodging may sometimes be prevented. Lodging in the principal oat-growing sections, however, is due oftener to the blowing over of the whole plant by heavy winds when the ground is soft from excessive rains than to actual weakness of the straw.

When the crop is desired for forage rather than for grain, the use of barnyard manure or fertilizers rich in nitrogen is often advisable, as nitrogenous fertilizers induce the rank growth necessary for the production of large yields of forage.

LIMING.

Liming alone is not likely to increase the yield of oats. On very sour soils or when used in connection with the plowing under of green-manure crops or stable manure, it may have a beneficial effect. Where lime was applied without manure at the Pennsylvania station it reduced the yield of oats, but where it was applied in connection with manure it increased the beneficial effect of the manure. This was in a 4-year rotation of corn, oats, wheat, and clover and timothy. The lime was applied at the rate of 2 tons to the acre previous to planting the corn crop.

While the application of lime or fertilizers to oats may not be directly profitable, the increased yields from succeeding crops may often more than make up the deficiency. This is particularly true when clover or a grass crop is to follow the oats.

OATS IN THE ROTATION.

PLACE IN THE ROTATION.

Among the factors which determine the place of the oat crop in the rotation are the effect of the preceding crop on the growth of the oats and the effect of the oats on the following crop. Ordinarily oats are not grown after a grass or clover crop, a cultivated crop being used to subdue the sod. In sections where virgin soil is being brought under cultivation oats are usually grown on "old land," wheat and flax being the crops which are ordinarily grown on sod land if a cultivated crop such as corn or one of the sorghums is not used. When grown on sod land, especially where the sod consists wholly or in part of clover or alfalfa, oats are inclined to grow rank and lodge. Where there is less trouble from lodging, as in some of the irrigated sections of the West, oats may follow clover or alfalfa.

At the South Dakota station, in a 3-year rotation including corn, oats, and wheat, little difference was noted between an oat crop following wheat and one following corn. The wheat crop, however, was materially better after corn than after oats, so that where these three crops are grown the best plan seems to be to grow the wheat after the corn, making the rotation corn, wheat, and oats. Similar results in favor of this sequence over the one in which wheat follows oats have been obtained at a number of the experimental farms conducted by the Bureau of Plant Industry in the Great Plains area, as reported in a recent publication.[a] Oats are less influenced by the effect of the preceding crop than are most other grains, so that where wheat, barley, and oats are the main crops the rotation, if one is practiced, is arranged to suit the other grains rather than oats. Where corn or some other cultivated crop is grown, oats usually follow the cultivated crop and are followed by grass or clover, which are usually sown with the oats.

COMMON ROTATIONS WHICH INCLUDE OATS.

A common rotation in Iowa and Illinois, and in the surrounding States as well, consists of corn, oats, and grass or clover. Usually this is a 5-year rotation, two crops of corn being grown in succession, followed by oats, with grass and clover seeded with the oats; the grass is allowed to remain for two years, either as meadow or pasture, and is then plowed up for corn. The rotation is sometimes shortened to four years, either two years of corn and one each of oats and grass or one year each of corn and oats and two years of grass. The first of these two rotations is the common one where clover alone is used as the hay crop. Where winter wheat can be grown

[a] Bulletin 187, Bureau of Plant Industry, U. S. Dept. of Agriculture.

it is customary to use it as a nurse crop for grass or clover. The common rotation where both oats and winter wheat are grown is corn, oats, winter wheat, and grass or clover for one or more years. In Maine and in some of the other potato-growing sections a common rotation consists of potatoes, oats, and clover, each one year. In the spring-wheat section, if corn is grown the common rotation is corn, wheat, oats, and grass. In some portions of the spring-wheat belt no rotation is practiced, particularly if corn and grass are not included among the staple crops. In the South oats occupy so small a portion of the cultivated area that they do not commonly figure in the rotation. A good rotation in this section which includes oats consists of corn, with cowpeas sown between the rows; oats, followed by cowpeas; and cotton. In the irrigated sections oats are sometimes grown in rotation with clover or alfalfa.

CLEARING THE LAND OF WEEDS.

As oats start into growth early in the season and soon make a dense shade, they are one of the best crops for clearing land of weeds. When used for this purpose, they should be sown rather more thickly than on land that is free from weeds. The crop may be cut for grain or for hay, as desired, but it should be harvested before many of the weeds that grow with it mature their seed. The land may then be pastured to keep down the later growth, or the weeds which develop after the oats are harvested may be cut with the mower or plowed under before they mature seed. If the field is plowed it should be disked or harrowed occasionally to destroy any weeds that start into growth. If fall grain is sown or if the land is used for a cultivated crop the next season, it will be practically free from annual weeds by the end of the second year.

USE AS A NURSE CROP.

Oats are very commonly used as a nurse crop for clover and grass, and sometimes, in the irrigated sections, for alfalfa. While not ideal for the purpose, as the foliage is rather too dense and the crop draws too heavily on the soil moisture, good results are usually obtained. The sudden change from dense shade to full exposure to the sun when the oats are harvested sometimes injures the young clover and grass plants. In dry seasons oats may take the moisture from the soil so completely as to check severely the growth of crops sown with them. Either barley or wheat is more suitable for use as a nurse crop, making less shade and requiring less water. Where oats are used the selection of small, early varieties is advisable, because they grow less rank and take less water from the soil than the later, larger-growing varieties. They also mature early enough

to harvest before the hot weather, which is likely to injure the young grass. Less seed should be used where oats are sown as a nurse crop than when sown for other purposes. Drilling is preferable to broadcast seeding, as the space between the rows admits light and air to the grass and clover plants.

USE AS A COVER CROP.

Oats are used to some extent as a cover crop in orchards in the Northern States. They draw rather heavily on the soil moisture, thus checking the growth of the trees and causing the young wood to mature fully before cold weather. Oats make a dense cover and thus protect the soil from intense summer heat. They also furnish considerable winter protection, though the plants make a close mat on the ground after heavy frosts and do not hold snow as well as some other cover crops. The use of peas or vetch with the oats increases the value of the cover, as these crops add nitrogen as well as humus to the soil. The proper dates and rates of seeding for cover crops depend largely on the locality and the practice of the particular fruit grower who uses them.

GROWING IN MIXTURES WITH OTHER CROPS.

Oats are sometimes grown in combination with other crops for the production of either hay or grain. In the United States the most common combination of this kind is oats and Canada field peas. Rape is often sown with oats, to be used as pasture for hogs or sheep after the oats are harvested. In Canada, barley and oats are commonly grown together and other grains are sometimes included in the mixture.

Where peas are grown with oats the crop is used as pasture or cut for feeding green or for hay. A common rate of seeding is 1 bushel of peas and 1½ bushels of oats to the acre, though an equal mixture is often used, sowing from 2 to 3 bushels to the acre. Where vetch does well it is sometimes substituted for the peas. A common proportion is 2 parts of vetch to 1 of oats. The combination of a legume with oats for pasture and soiling purposes increases both the yield and the feeding value of the crop, while the legume adds nitrogen to the soil.

Numerous experiments at the Ontario Experimental Farm have shown that better yields of grain are obtained where barley and oats are sown together than where either is sown alone. This combination is a very popular one in Ontario and its use is increasing. The area of mixed grains, principally barley and oats, grown in the Province of Ontario in 1908 was more than 450,000 acres, while barley alone was grown on 732,000 acres and oats alone on 2,774,000 acres. It is necessary to use a rather early variety of oats when sowing with

barley in order that the two crops may ripen together. These combination crops are usually used for feeding on the farms where grown, and are not readily marketable except as feed grain.

In an experiment at the Ontario Experimental Farm to determine the value of various grain mixtures, barley and oats together gave better yields than either alone or in any other combination of oats, barley, spring wheat, and peas. In another experiment, to determine whether a mixture of 1 bushel of oats and 1½ bushels of barley could be improved by the addition of a small quantity of other grain, additions of one-half bushel of flax, emmer, spring wheat, and hull-less barley were made on different plats. A 5-year test showed that higher yields of grain were obtained from the barley-and-oats mixture without the addition of any other grain. Various proportions of barley and oats and different rates of seeding were tested at this farm for six years to determine which gave the highest yield. It was found that sowing 1 bushel each of oats and barley produced the largest yield of grain. Similar results were obtained in a duplicate experiment conducted in 1907 and 1908, although the difference in yield of several of the combinations was slight.

A small quantity of rape seed, 1 to 2 pounds, is often sown with oats. It is good practice, however, to sow the rape two or three weeks after the oats are sown, covering the seed by harrowing lightly. If sown at the same time as the oats it makes so much growth that it interferes with the harvesting of the oats. If the oats are cut with a rather high stubble the rape, if the season is favorable, will at once start into vigorous growth and make excellent pasture for sheep and hogs. Sheep, in particular, do well on this pasture, as they glean any grain which may have been left by the binder. Rape sown in this way may also be cut for feeding green, or when sown with the oats or with oats and peas the entire crop may be cut green, thus furnishing a large yield of succulent feed.

PREPARATION OF THE SEED BED.

Less attention is ordinarily given to the preparation of the seed bed for oats than for any other field crop. A common method in the corn belt, where the oat crop almost invariably follows corn, is to sow the seed broadcast on corn land without preparation. This method is now less used than it was a few years ago, when its prevalence was well shown by an inquiry sent out by the Iowa station in 1905. Of 452 farmers who replied to the list of questions regarding the preparation of the land for oats, more than 70 per cent neither broke nor burned the cornstalks before seeding to oats, only 13 per cent disked the ground before seeding, and a still smaller proportion

harrowed before seeding. In other words, nearly three-fourths of those who replied sowed their oats broadcast on cornstalk land without preparation of any kind. Figure 1 shows the end-gate seeder commonly used in broadcast seeding, while figure 2 shows this machine in operation in a field where the cornstalks are still standing.

A good seed bed can hardly be prepared with fewer than two diskings, and usually at least one harrowing is necessary. Where oats are to be sown on corn land on which the stalks are still standing it is good practice to break the stalks before disking. This can readily be done, especially on a frosty morning, by dragging a heavy pole or iron rail broadside across the field. The stalks can then be cut with a disk harrow much more readily than if left standing. Where there is much trash on the land it is sometimes advisable to rake and burn the stalks and weeds before disking. This is common practice in some sections. Ordinarily this humus-making material should not be destroyed, but should be worked into the soil. If the disks of the disk harrow are sharp they will cut the stalks into short pieces, which soon decay, and much of the trash will be covered by the disking and harrowing. Breaking the stalks and cutting them with a stalk cutter in the fall hastens their decay. A disk harrow in operation on cornstalk land is shown in figure 3, while figure 4 shows a stalk cutter designed to cut two rows of cornstalks.

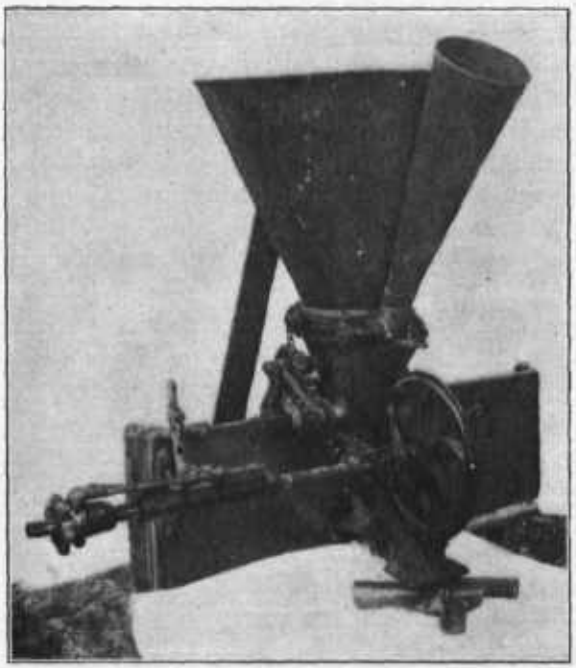

FIG. 1.—End-gate seeder commonly used for the broadcast seeding of grain. The smaller hopper is for grass or clover seed. Power for operating this seeder is supplied from one of the rear wheels of a wagon by means of sprocket wheels and a chain.

It is always advisable to sow oats as early in the spring as the land can be worked, but proper preparation should not be sacrificed to gain a little time in getting the seed into the ground. Oats do best when sown in a rather firm seed bed, with 2 to 3 inches of loose, mellow soil on the surface. This can best be secured on cornstalk land by breaking the stalks, double-disking either by lapping half or cross disking, and thorough harrowing with the spike-tooth harrow.

Lapping half with the disk harrow leaves the surface more nearly even than when the field is cross-disked. The disks should be set to

FIG. 2.—The end-gate seeder shown in figure 1 in operation in a field of standing cornstalks—a common but not a good method of seeding.

run 3 or 4 inches deep. After the seed bed is in good condition the seed should be sown and the field again harrowed.

FIG. 3.—Disking corn land preparatory to sowing oats.

The land is seldom plowed for oats which follow a cultivated crop. Spring plowing is not usually profitable, as there is little time to allow

the subsurface to become compact, and the land is rarely in proper condition to plow before the oats should be sown. Soils which are not likely to blow or run together can sometimes be plowed in the fall to advantage, particularly if grass seed is to be sown with the oats. A fine, smooth, mellow seed bed can thus be prepared. Fall-plowed land should be double-disked about 3 inches deep before seeding and harrowed both before and after seeding.

At the Ohio station in a 6-year test in which plowing 6 to 7 inches deep was compared with disking 3 or 4 inches deep, with thorough subsequent preparation in both cases, an average yield of 52.8 bushels to the acre was harvested from the plowed and 48.7 bushels from the disked land, a gain in favor of plowing of 4.1 bushels. Sowing on spring-plowed land at the Kansas station gave an average yield for five years of 27.4 bushels to the acre, as compared with 25.5 bushels from sowing on fall-plowed and 25.1 bushels from sowing on unplowed land. A moderately loose seed bed with a firm subsoil, such as is ordinarily produced by thorough disking and harrowing, gave better results at the Illinois station than either a very loose or a firm seed bed.

FIG. 4.—Stalk cutter designed to cut two rows of cornstalks.

PREPARATION OF THE SEED.

CLEANING AND GRADING.

Seed oats should be carefully screened and graded before sowing. This work is ordinarily done with the fanning mill, the light oats and some of the trash being taken out by a current of air, while the small oats and most of the weed seeds are removed by means of screens. The process should take out one-third or one-fourth of the oats, but if the seed is very light a much larger proportion should be removed by the fans. Many of the small, light oats will not germinate at all, while others produce weak plants, which materially reduce the yield. Screening also greatly reduces the proportion of weed seed, thus preventing the spread of weeds and further favoring the growth of the oat crop.

Experimental tests of graded seed naturally fall into two classes, one in which the same weight or measure of all the different grades of

seed is sown and one in which the same number of seeds is sown on the different plats. Most of the tests belong to the first class, in which the same rate of seeding by weight is used for all grades. In a test of this kind which was conducted for eight years at the Kansas station, heavy seed gave an average yield of 30.9 bushels to the acre, common seed 29.9 bushels, and light seed 27.5 bushels. The common seed used was the seed as it came from the thrasher, the light and heavy grades being obtained by running the seed through a fanning mill. These grades were usually taken from the ordinary seed; but in the last year of the experiment, when the greatest difference was noted, the heavy seed was taken from the heavy grade of the previous year and the light seed from the light grade. In an experiment conducted at the Ohio station for seven years average yields of 46.3, 44.8, and 42.6 bushels were obtained from the heavy, common, and light seed. The yield of straw and the weight per bushel were both slightly heavier from the heavy seed than from either of the other grades.

At the Ontario Experimental Farm even more marked results in favor of large seed were secured, using the same number of grains of each grade to the acre. In a 7-year test average yields of 62, 54.1, and 46.6 bushels to the acre were obtained from heavy, medium, and light seeds, respectively. In a test in which the heavy seed was selected from the heavy grade and the light seed from the light grade of the previous year, the difference in yield and in weight per bushel in favor of the heavy seed continually increased. The test was conducted for twelve years. The difference in weight per bushel in favor of the heavy seed in the first 4-year period was 3.2 pounds, in the second period 6 pounds, and in the third period 9.5 pounds. The differences in yield per acre were 10.4, 15.8, and 22.4 bushels, respectively, for the three periods.

TREATING FOR SMUT.

The yield of grain and the quality of the crop can also be materially increased by treating the seed for smut with formalin or hot water.[a] An easy and effective method of treatment is to sprinkle the seed oats with a solution made of 1 pound of formalin to 40 gallons of water. The seed should be spread out on a clean floor, thoroughly sprinkled, and shoveled over until all of the grain is well moistened. It should then be covered with blankets or canvas and allowed to stand for several hours. It can then be sown at once or spread out in a clean place to dry. The seed will run through the drill much more readily if dried before seeding. The rate of seeding should be somewhat increased to allow for the swelling of the seed.

[a] A full description of these methods of smut treatment is contained in Farmers' Bulletin 250, U. S. Dept. of Agriculture, 1906.

Care should be used not to put the treated seed into sacks, bins, or machinery in which the smut spores have not been killed by treatment. The cost of the smut treatment was estimated by Professor Close, of the New York State station, at 1.4 cents to the bushel.

SOWING THE SEED.

DATE OF SEEDING.

One of the greatest essentials in growing oats is to get the seed into the ground early. This crop grows best in cool climates and in cool weather, and is often materially injured by a few hot days when it is near maturity. Frosts or even hard freezes after the seed is sown seldom injure it, so that, as a rule, oats should be sown just as soon as the ground is in condition to work in the spring. In fact, a few farmers in the Northern States are now sowing the ordinary spring varieties of oats in the fall, just before the ground freezes. The seed usually does not germinate in the fall, but begins growth with the first warm days of spring. The advantages claimed for this practice are that the fall seeding lessens the spring rush of work and that the seed gets an earlier start than is possible with spring seeding. The dangers incident to fall seeding include germination in the fall and subsequent winterkilling, freezing after the seed germinates in the spring, and injury from alternate freezing and thawing and continued cold, wet weather. While the practice has not yet been tested enough to justify a statement of its value, it seems to be worthy of limited trial, particularly in the drier sections, where it is most likely to prove a success. Some Ohio and Indiana farmers have grown good crops of oats from seed sown broadcast on the snow in February, depending on later freezes and thaws to cover the seed. Seeding in this way can not be generally recommended, as the chances of loss are too great.

All tests conducted by the experiment stations are favorable to early spring seeding as compared with later seeding. In time-of-seeding tests conducted for five years at the Illinois station the earliest date gave the highest yield in three of the tests, while the second and third dates, respectively, gave the highest yields in the other two tests. In these tests seeding was begun as early as possible in the spring and continued at intervals of about one week to May 1. The best dates for seeding seemed to be from March 25 to April 8. Similar results in favor of early seeding were obtained in a 5-year test at the Kansas station. The highest yield was from seeding about March 8, and there was a material decrease in yield for each week of delay in seeding. Seeding the first week in April yielded only about half as much as that done early in March. A later

test at this station showed better results from sowing in the latter part of March than at an earlier or a later date.

The exact date of seeding naturally depends on the locality and the season. Seeding of spring oats begins in the South in the latter part of January or early in February, and in the Northern States is not completed until May. The best date in Kansas, Missouri, southern Illinois, and Kentucky ranges from March 10 to March 25. For Pennsylvania, Ohio, Indiana, central and northern Illinois, Iowa, and Nebraska the best date is usually from March 25 to April 15, though a somewhat later date may sometimes be necessary. In the Northern States seeding during the latter half of April is advisable whenever possible, though in favorable seasons seeding before the middle of the month can often be done to advantage, and in unfavorable ones, in the extreme North, May seeding is necessary. In the Rocky Mountain and Pacific States seeding is governed so largely by local conditions that no definite dates can be given. In some districts, owing to the distribution of the rainfall, late seeding may be more uniformly successful than early seeding.

RATE OF SEEDING.

The rate of seeding depends on the locality, the condition and fertility of the soil, the method of seeding, and the size of the seed. As with other crops, less seed is required in dry than in humid sections. Fertile soils require less seed than poor ones, as on rich land the plants grow larger and tiller more. More seed should be sown on weedy land or on land not well prepared than on clean, mellow soil. Drilling requires less seed than sowing broadcast. More bushels of large-grained than of small-grained oats should be sown on an acre. The number of grains in a measured bushel of oats ranges from 500,000 to 750,000, according to the variety. The large-grained varieties usually grow ranker and the plants occupy more space than the small-grained ones, but the difference in the size of the plants does not equalize the difference in thickness of stand caused by the greater number of plants produced by a bushel of small-grained oats.

In general, the rate of seeding in the upper Mississippi Valley ranges from 8 to 12 pecks to the acre, but in the drier sections of the West this rate is reduced by half. In the irrigated sections 6 to 8 pecks is the common rate. Where the usual rate in broadcast seeding is 12 pecks, 10 pecks will be sufficient if the seed is drilled.

Many experiments have been conducted to determine the best rate of seeding in different localities. These experiments show, in general, that tillering depends very largely on the thickness of the stand and that within certain limits the plants on thinly seeded

plats will tiller sufficiently to bring the number of stalks up to that produced by thick seeding. Thus, there is often little difference in the yield of grain or straw harvested from widely differing rates of seeding. Sixteen tests at the Ohio station, in which oats were seeded at rates varying from 4 to 11 pecks to the acre, indicated that the heaviest seeding was most profitable. There was little difference, however, in the yields of seeding at the rates of 8, 9, 10, and 11 pecks. In general, the weight of straw was greatest from the lightest seeding, and the weight per bushel and the yield of grain greatest from the heaviest seeding. A 9-year test at the Indiana station showed best results in drilling when the seed was sown at the rate of 8 pecks, though there was little gain over 9, 10, and 11 pecks. Seeding at the rate of 10 pecks is recommended when ordinary methods of preparation and seeding are followed.

In a 6-year test at the Illinois station, the heaviest yield of grain was produced by seeding at the rate of 10 pecks. At the Iowa station slightly better yields were obtained from sowing a small-grained, early variety at the rate of 12 pecks than from 6, 8, or 10 pecks, but materially increased yields were obtained from seeding a large-grained, later variety at the 12-peck rate. In Nebraska the highest net return from a small, early variety was from seeding at the rate of 8 pecks when the seed was drilled and at the rate of 10 pecks when the seed was sown broadcast. In a 6-year test at the Kansas station the highest yield was obtained from the heaviest seeding, 16 pecks, though the increase over seeding at the rate of 10 pecks little more than made up for the extra seed required.

METHOD OF SEEDING.

Two methods of seeding oats are in common use, drilling and sowing broadcast. The greater portion of the oat crop is sown broadcast and the seed covered with the disk or smoothing harrow. The ideal method of seeding is one which distributes the seed evenly over the ground and covers it to a uniform depth of about 1 inch. Neither of these results is obtained in broadcast seeding, but both results are possible by drilling. Less seed is necessary, the depth of covering is more nearly uniform, the seed germinates more evenly, and the growth throughout the season is better when the seed is drilled. A grain drill in operation on well-prepared land is shown in figure 5.

While some experiments show slightly better results from broadcast seeding than from drilling, others show a decided gain from drilling. The Illinois station compared drilling and broadcast seeding at Urbana for three years, sowing half of each of their variety plats in each manner. All other conditions were the same, except that in one of the three years during which the test was con-

ducted 4 bushels to the acre were sown on the broadcast plats as compared with 3 bushels on the drilled plats. The average yield for all plats for the three years was 5.3 bushels to the acre annually in favor of drilling. Similar tests for three years at Dekalb, Ill., gave an average gain for drilling of 2.7 bushels, while two years' work at Sibley showed a gain for the drilled plats of 3.6 bushels to the acre. In addition to the increased yield, the advantages of drilling were stated to include evenness of stand, regularity of growth, uniformity of heading and ripening, and smaller quantity of seed necessary. It was also observed that clover was less liable to injury when the grain crop was removed if sown with drilled oats than if sown in broadcasted oats.

FIG. 5.—Grain drill in operation on well-prepared ground.

In a 7-year test at the Kansas station the use of the drill increased the yield about 4 bushels to the acre, broadcast seeding averaging 26.24 bushels and drilling 30 bushels. In a 6-year test at the Ohio station slightly better yields were obtained from broadcast seeding than from drilling 2 inches deep. At this station, however, when different depths of drilling were compared, materially better yields resulted from drilling 1 inch deep than from drilling at depths of 2, 3, or 4 inches. It is quite probable that drilling 1 inch deep would have given better yields than sowing broadcast. The Nebraska station obtained better yields from sowing broadcast than from drilling, though the gain was but 0.9 bushel, or 1.5 per cent, in a 4-year test. A material increase was obtained from drilling at the Iowa station.

DEPTH OF SEEDING.

Most of the experiments favor shallow seeding. At the Ohio station the average of two years' results showed a yield of 3.56 bushels to the acre greater for the 1-inch than for the 2-inch depth, and 7.73 bushels to the acre greater for the 1-inch than for the 3-inch or the 4-inch depth. Covering only 1 inch deep gave better results at the Illinois station than sowing at greater depths. At the North Dakota station in 1898 slightly heavier yields on the average were obtained from the deeper seedings, though the largest yield of all was from the shallowest seeding, 1 inch.

If the seed is sown broadcast it should be covered by a shallow disking or thorough harrowing. Usually, if the field has been double-disked and harrowed and is in good condition before seeding, harrowing twice will cover the seed sufficiently. At best, however, it is impossible in broadcast seeding to cover all the seed to the same depth; some seed is left on the surface and does not germinate at all, while a small portion is covered so deep that its germination is considerably delayed.

TREATMENT AFTER SEEDING.

The yield of oats can sometimes be increased by treatment after the crop is sown. The most common methods for thus increasing the yield include cultivation, spraying to kill weeds, and irrigation.

CULTIVATION.

On loose soil rolling can sometimes be done to advantage after the seed is sown. The Wisconsin station found that the temperature of rolled soils was higher than that of soils not rolled. For this reason germination and early growth can sometimes be hastened by rolling. On soils which are inclined to pack and bake the roller should be used with caution, as its use is likely to increase this tendency. A light harrowing after rolling, to break the crust and hold the soil moisture, is beneficial.

On land which has been plowed in the spring or which for some other reason is loose and open the use of the roller or the subsurface packer may sometimes increase the yield of oats. At the Canadian Experimental Farm at Lacombe, Alberta, on a soil of loose texture containing considerable humus, the use of the packer after seeding increased the yield in 1908 and 1909 from 69.45 bushels for the unpacked to 83.36 bushels for the packed plats. In 1908 one variety was grown, using three rates of seeding, while in 1909 two varieties, each at two rates of seeding, were grown.

Cultivation of small grain with the harrow or weeder is seldom practiced, but experiments indicate that this work can often be done to advantage, particularly in regions of light rainfall. This cultiva-

tion usually takes the form of two or three harrowings with the spike-tooth harrow or weeder. If the harrow is used, the teeth should be set rather slanting, so as not to pull out the young grain. Cultivation with the harrow is sometimes of advantage on very weedy ground, even where the rainfall is ample, as the weeds are readily killed when small. The harrow should be used, however, only on drilled fields and only after the young grain is well rooted. Harrowing at intervals of a week, beginning about three weeks after the grain is sown and continuing until it begins to make stems, is an efficient method of checking weed growth and conserving moisture for the oat crop. If grass or clover seed is sown with the grain no cultivation should be given.

Experiments conducted at the Nebraska station indicate that harrowing drilled oats is profitable in seasons when the rainfall is normal or below, but injurious when it is above normal. Cultivation of grain sown broadcast resulted in a loss, even in dry years, as a considerable number of the plants were pulled out by the harrow. The average difference in a 7-year test in favor of harrowing grain in 6-inch drills was 4.8 bushels to the acre. In the four years in which the cultivation of drilled grain was compared with that sown broadcast, the average increase from cultivating drilled oats was 5.3 bushels, or 9.1 per cent, while the loss from cultivating oats sown broadcast was 1.9 bushels, or 3.3 per cent. The cultivation generally consisted of two or three harrowings with a smoothing harrow or weeder. The weeder was preferred for this work, as it did not carry trash and was less severe on the young plants. The harrowings were done at intervals of a few days, usually from three to five weeks after seeding. Sowing the oats in drills 12 inches or more apart gave lower yields than in drills 6 inches apart, even though extra cultivation was given. A single year's test at the Kansas station was unfavorable to the cultivation of drilled oats.

Large weeds which develop with the crop, if not too numerous, can often be removed by pulling or cutting without much injury to the growing crop. The gain from preventing the spread of the weeds should more than repay the necessary loss from trampling in removing them, which will be slight, particularly in drilled oats.

SPRAYING TO KILL WEEDS.

Several of the common weeds of grain fields can be kept in check by spraying. Wild mustard, which is particularly prevalent in portions of Wisconsin, Minnesota, North Dakota, and South Dakota, is readily destroyed by spraying with iron-sulphate[a] (copperas) solution,

[a] Detailed directions for spraying with iron sulphate are given in Bulletin 179, Wisconsin Agricultural Experiment Station, and in Bulletin 80, North Dakota Agricultural Experiment Station.

using 75 to 100 pounds of granulated iron sulphate to 50 gallons of water. Copper sulphate (blue vitriol or bluestone) is also effective, using 12 to 15 pounds to 50 gallons of water. The usual application is 50 to 55 gallons of the solution to the acre. Spraying can be done most effectively before the older weeds come into blossom, as the pods, if allowed to develop, will ripen seed even after the leaves are killed by the spray. Spraying will not seriously injure the young grain or grasses, while it kills or materially checks the growth of mustard and many other weeds. Clover and alfalfa are both rather severely injured by the application of any chemical that will kill weeds. The cost of spraying with the iron-sulphate solution is about $1.25 to the acre. Small patches may be sprayed with a bucket pump or a knapsack sprayer, but for large fields a wagon fitted with a tank and suitable nozzles should be used. These machines can be purchased from dealers in spraying apparatus. The type of machine commonly used for spraying potatoes on a large scale is equally effective in spraying to kill weeds.

Professor Bolley, of the North Dakota station, found the iron-sulphate solution effective in checking or killing wild mustard, ragweed, kinghead, cocklebur, corn cockle, bindweed, and a number of other serious weed pests in the Red River Valley. Professor Olive, of the South Dakota station, states that the weeds which were entirely killed by the spray in an experiment conducted by him included mustard, ragweed, bindweed, milkweed, pigweed, and peppergrass.

CUTTING BACK TO PREVENT LODGING.

At the Iowa station cutting back the plants to the base of the third leaf above the ground when most of the plants had produced the fifth leaf caused the crop to mature slightly later, but materially decreased the amount of lodging and increased the yield. This experiment was conducted for but one year, but it is in line with the rather common practice of pasturing winter grain crops when the growth becomes too rank for the best production of grain.

IRRIGATION.[a]

Oats require rather more water for their best development than wheat, though there is great difference in the varieties of both grains in this respect. It is also generally believed that oats require more water than barley, though some experiments indicate the contrary. Irrigation of oats is practiced to a considerable extent in the Rocky Mountain and North Pacific States, particularly in Montana, Idaho,

[a] Farmers' Bulletin 399, U. S. Dept. of Agriculture, 1910, entitled "Irrigation of Grain," describes the methods of applying water to grain crops and gives other details of irrigation practice.

and Utah. The water is ordinarily applied at two irrigations, though three or four are frequently given. When two applications are made the first is usually just before heading begins, while the second and much heavier one is at the time when the grain begins to fill. Opinions vary greatly as to the supply of water needed by this crop. It is probable that 15 to 20 inches is the most profitable quantity, though where plenty of water is available much more is ordinarily applied. The quantity of water to be applied depends upon the nature of the soil. The danger, especially where water is plentiful, is in overirrigation.

The average depth of water applied to oats at the Wyoming station was 21 inches, slightly more than was applied to wheat and barley. The largest return to the acre was received at this station when 43.6 inches of water were applied, but the largest return per inch of water applied was with an application of 16.6 inches. This leads to the conclusion that when one has a large area of land and a small water supply, the best use of the available supply will probably be made when a larger area is irrigated with it than is common.

At the Nevada station the largest acre yield of oats was obtained from two irrigations, with a total application of 10.7 inches of water. An increase in the number of irrigations and in the depth of water supplied decreased the yield. The largest yield to the acre-foot of water was obtained from one irrigation, using 7.2 inches of water. The Utah station found that the maximum increase in the yield of oats for each additional inch of water was reached at about 15 inches. From the results at this station it was computed that where 30 inches of water on 1 acre would produce 85 bushels of oats the same quantity applied to 2 acres (15 inches to the acre) would produce 113¼ bushels. The net profit from this extension of the irrigated area, however, is much less than the figures indicate, owing to the increased cost of plowing, seeding, and harvesting.

HARVESTING THE CROP.

CUTTING.

Oats are usually cut with the grain binder, though in the drier sections the header is used, and occasionally the crop is harvested with the combined harvester and thrasher. A binder in operation in a field of oats in North Dakota is shown in figure 6. When the straw is very short, owing to dry weather, or when the crop is badly lodged, cutting with the mower may be necessary. The grain may then be raked and put into cocks, which should be well built so as to shed rain. The proper time to cut oats is when they are in the hard-dough stage. If cut before this time, the grain is not well filled,

shrivels in curing, and is light in weight. If allowed to become fully ripe before cutting, a considerable portion of the crop shatters out and is lost in harvesting, and the danger of damage from storms is also increased. Where a large acreage is to be harvested it is advisable to begin cutting when the grain is about to pass out of the milk

FIG. 6.—Grain binder at work in an oat field in North Dakota.

stage, otherwise a considerable portion of the crop is likely to become too ripe before it can be cut.

SHOCKING.

If the grain is ripe or in the hard-dough stage when cut it may be placed at once in round shocks, which should be capped to prevent damage from rain and dew. The best quality of grain can be harvested under these conditions. If the grain is green or if the bundles contain a considerable quantity of weeds, they should be allowed to cure for a few hours before shocking, and should then be placed in long shocks, which may or may not be capped. Long shocks allow the sun and air to penetrate much more readily than round ones, and are to be preferred when the grain is not well cured. A common form of long, uncapped shock in which most of the grain is exposed to the weather is shown in figure 7; a round, capped shock in which practically all the grain is protected from weathering is shown in figure 8. Equally good protection is afforded by capping the long shocks. Grain which is wet from dew or rain should be allowed to dry before it is placed in shocks. In sections where strong winds prevail during the harvest season capping is not advisable, as the caps blow off and the grain in the cap sheaves is injured by contact with the ground.

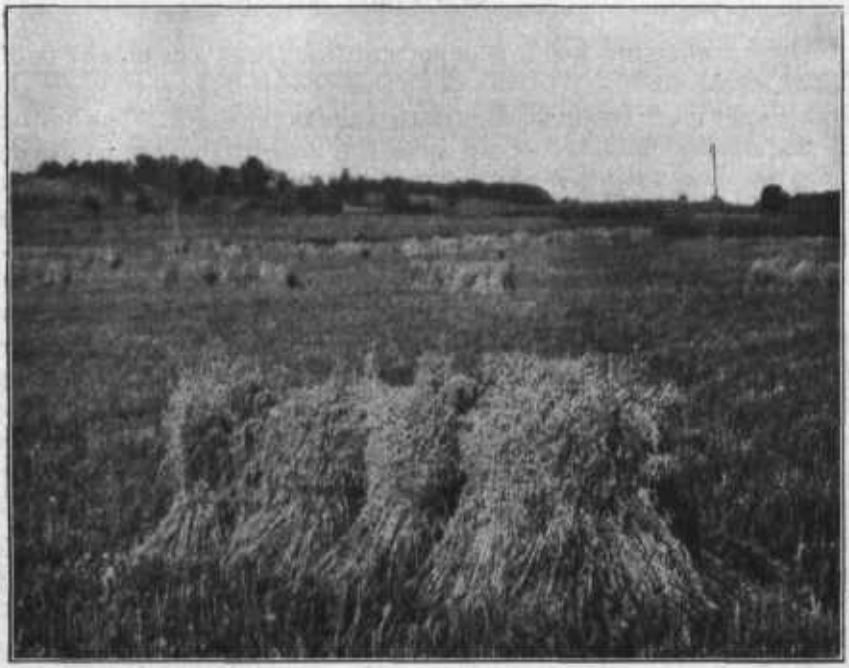

FIG. 7.—A long, uncapped shock in which practically all of the grain is exposed to the weather.

FIG. 8.—A well-built, round shock, capped to protect most of the grain from weathering.

STACKING.

Where grain is stacked it is important that the stacks be well built. If the stacks are so carelessly put up that they will not shed water the grain might much better be allowed to stand in the shock. The bottom of the stack should be set up from the ground slightly by laying down old rails or other material to keep the grain from coming in contact with the earth. This will prevent the absorption of moisture from below. The shape of the stack is less important than the manner in which the bundles are laid. They should be so placed that only the butts are exposed, and so that water will readily run off the sides of the stack and not penetrate enough to wet the grain. The round form of stack probably sheds water better than the long ricks sometimes constructed. If the rick is built the top should be covered with straw or wild hay to keep out water.

SHOCK VERSUS STACK THRASHING.

Whether oats are to be stacked or allowed to remain in the shock until they are thrashed depends very largely on local conditions. If there is a reasonable certainty that a thrashing outfit will be available after the grain has had time to cure in the shock but before it is exposed unnecessarily to weathering, the relative cost of shock and stack thrashing is the point on which the decision must be made. According to investigations conducted by the Minnesota station in cooperation with the Bureau of Statistics of the Department of Agriculture, the labor cost of thrashing from the shock in southern Minnesota was 4.3 cents to the bushel, while that of stack thrashing was 5.2 cents. In northwestern Minnesota the relative labor cost of the two operations was 3.6 cents and 4.9 cents. It is probably safe to assume that stacking adds about 1 cent a bushel to the cost of producing oats.

In the report of the investigations just mentioned the relative merits of shock and stack thrashing are thus compared:

> The possibility of improving the grade of grain enough to pay the additional cost of stacking and stack thrashing depends in any locality upon the availability of machines, the availability of labor, and the climatic conditions prevailing at harvest. Intelligent stacking of grain during a majority of Minnesota harvests is cheap insurance against bleached, sprouted, and bin-burnt grain. If the weather is favorable and a machine can be put in the field as soon as the grain is fit to thrash, a slight saving will be made as compared with stacking and stack thrashing. On the other hand, if the shocks must weather for several days or, in some cases, for several weeks before a machine can be obtained, the loss in grade is considerable and stacking the grain would have been profitable.

The conclusion reached in this report is that on the ordinary small farm in Minnesota stacking is to be regarded as the better practice.

In general, conditions during harvest in the greater portion of the oat-growing sections are similar to those in Minnesota, and on small farms stacking oats is generally to be recommended. On the larger farms of the West where there is less danger from rains and where a thrashing machine is available at the time the grain is ready to thrash, shock thrashing will no doubt continue to be the general practice.

THRASHING.

The grain should be thoroughly dry when it is thrashed, as it not only thrashes better but there is danger that both the grain and the straw will heat and mold if thrashed when damp. It is important to see that the thrashing machine is thoroughly cleaned before thrashing is begun. This will not only prevent mixing the grain with that from a neighboring farm, but will also check the spread of weeds which may be carried from place to place in the separator. The operation of the machine should be carefully watched to see that all the grain is removed from the straw and that the separation of the grain from the chaff and dirt is as complete as possible. The concaves should be so set that they will remove all the grain, but not so close that they will hull it. The straw should be carefully stacked, so that it will be injured as little as possible by rains. If there is available room, running the straw into the barn is both economical and convenient.

STORING THE GRAIN.

Oats, like other grains, should be stored in bins that are protected from the weather and well set up from the ground, so that the grain will not absorb moisture. The grain should be dry when it is put in the bin and should be kept dry, as otherwise there is considerable danger that it will become musty and discolored. Mustiness not only lowers the feeding value of oats, but may make them dangerous to the health of the animals. It is important that the bins be so constructed that they may be kept free from vermin and so that the grain can be easily handled. Placing the bin as near as possible to where the oats are to be used is desirable. An apparatus for elevating the grain into the bin is shown in figure 9. In sections where grain weevils and other insects seriously affect stored grain, the building of tight bins which can be fumigated is sometimes necessary.

YIELDS.

In the United States the highest yields of oats are harvested in the North Pacific and Rocky Mountain regions where the crop is irrigated or the rainfall is heavy. Under irrigation the production of 100 to 125 bushels to the acre is not uncommon, while yields of 150

to 175 bushels are sometimes reported. The average yield of the United States for the ten years from 1900 to 1909, as reported by the Bureau of Statistics of the Department of Agriculture, has been slightly less than 30 bushels. New York, Michigan, Wisconsin, Minnesota, and North and South Dakota ordinarily report average yields of 32 to 37 bushels. Pennsylvania, Ohio, Indiana, Illinois, Iowa, and Nebraska usually average rather lower, from 27 to 35 bushels, while the lowest figures of all are obtained in the Southern States, where the average production ranges from 12 to 20 bushels to the acre. Individual farmers in all these States harvest much better yields than the figures just given. In several of the States where irrigation is practiced the average yield is more than 40 bushels

FIG. 9.—Apparatus for elevating grain from the wagon to the bin.

to the acre. In comparison with the average yield of the United States of about 30 bushels to the acre, the average yield of oats in Germany is about 50 bushels, in the United Kingdom 45 bushels, in France 28 bushels, and in Russia 20 bushels. The cool, moist climate of Germany and of the United Kingdom is particularly well adapted to the production of high yields of oats, which are further increased by the good methods of cultivation practiced.

COST OF PRODUCTION.

Estimates of the cost of producing an acre or a bushel of oats vary greatly. Much depends on the labor used in preparing the land for seeding, the yield produced, the cost of thrashing, and the rent or interest charges on the land. Professor Hume, of the Illinois

College of Agriculture, estimated the cost of producing 33 bushels of oats to the acre in central Illinois, in the cheapest possible manner, at $5.45, or 16 cents a bushel, land rental not included. The cost of producing oats in three different sections of Minnesota was reported by the Minnesota station as $9.84, $8.83, and $6.31 to the acre, respectively, with land rental included. Owing to the difference in yield the cost of producing a bushel of oats in these three sections was practically the same, 21 cents. The cost of producing a bushel of oats at Ottawa, Canada, was estimated in 1903 at 21.7 cents. The acre cost of production under irrigation is much greater than where there is no irrigation, but the cost per bushel is not materially increased, owing to the greater yields. Farm estimates of the cost of production are usually lower than the figures just given, as farmers often fail to take into account the depreciation in value of the farm machinery and other items which are properly chargeable to the crop.

The ordinary cost of producing 33 bushels of oats to the acre in Illinois, with the land rental included, according to Professor Hume, is $11.84. At 26 cents, the prevailing price per bushel in Illinois at the time this estimate was made, this crop would sell for $8.52 an acre, or at a loss to the farmer of $3.32, while a crop of 100 bushels, which cost $20.21 to produce, would sell for $26, or a profit of $5.79. At 38 cents, the average price in Illinois in December, 1909, the 33-bushel crop would return a small profit, while the 100-bushel crop would return a liberal one, at least $15 to the acre, allowing for a slight increase in the cost of production. At 26 cents, the average farm price in Minnesota for 1904, 1905, and 1906, when the estimates of cost of production in that State were made, the net profit in the three sections was $2.38, $2.35, and $1.36 per acre, respectively. The narrow margin of profit shown in all these figures indicates the necessity for increasing the acre yield of oats if the crop is to be grown at a profit.

VARIETIES ADAPTED TO DIFFERENT SECTIONS OF THE UNITED STATES.

GENERAL STATEMENT.

Varieties of oats may differ in the size, shape, or color of the grain, in the length of time they require from seeding to maturity, in the shape and size of the panicle, in the yield of grain or of straw, and in the time when they may be sown. The grain may be large, medium, or small; it may be long and slender or short and plump; the color may be white, yellow, black, gray, or brownish-red. The grains of four varieties of oats which differ in size, shape, and color are shown in figure 10. The difference in the time necessary to reach maturity

for different varieties at any given place is from fifteen to twenty-five days; all varieties mature more quickly in the central portion of the United States than in the northern part. In the southern and central portions of the country the earliest varieties may mature in eighty-five to ninety days; in the cooler climate of the north the later varieties may require one hundred and twenty-five to one hundred and forty days. The panicle may be open and spreading, or closed and turned to one side (side oats), or it may be anywhere between the two extremes. Heads of both side and spreading oats are shown in figure 11. Two varieties which are very similar in appearance may differ widely in yield of grain or of straw. Most

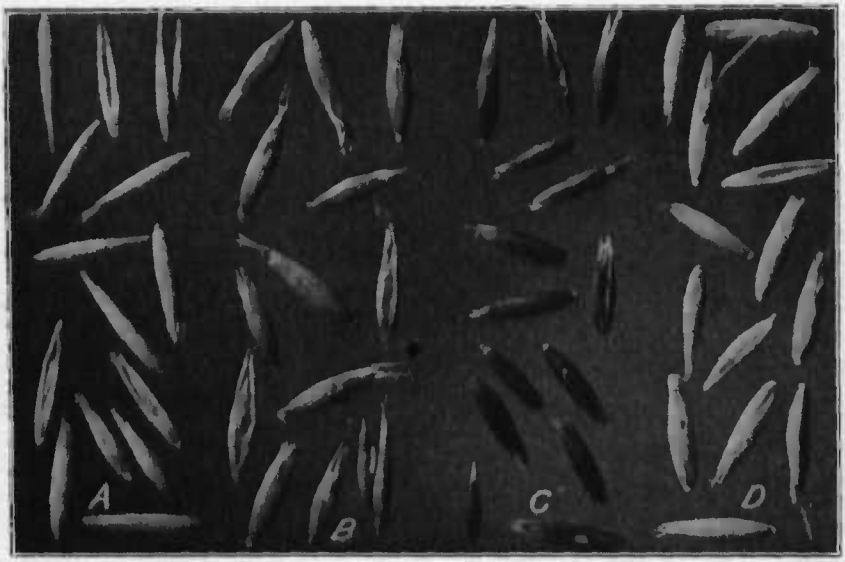

FIG. 10.—Grains of four varieties of oats which differ in shape, size, and color. *A*, Sixty-Day, with medium-sized, slender, yellow grain; *B*, Red Rustproof, with large, plump, reddish-brown grain; *C*, North Finnish Black, with medium-sized, moderately plump, black grain; *D*, Swedish Select, with large, plump, white grain.

of the varieties grown in the United States are adapted to spring seeding, but a few, like Winter Turf, are sown in the fall in the Southern States, while others, like Red Rustproof, may be sown either in the fall or the spring.

The number of varieties of oats grown in the United States is very large, though the number well adapted to the conditions in any particular section is comparatively small. Several hundred varietal names are to be found in the catalogues of American seedsmen, but in many instances different names are applied to the same variety by different seedsmen or in different sections of the country. A good example of this is to be found in the Winter Turf oat, which is variously known as Gray Winter, Virginia Gray, Turf, Grazing,

Virginia Winter, and Winter Turf, while several similar names are less commonly applied to it. Every year new varieties of oats are offered by seedsmen, while other names are omitted from their lists,

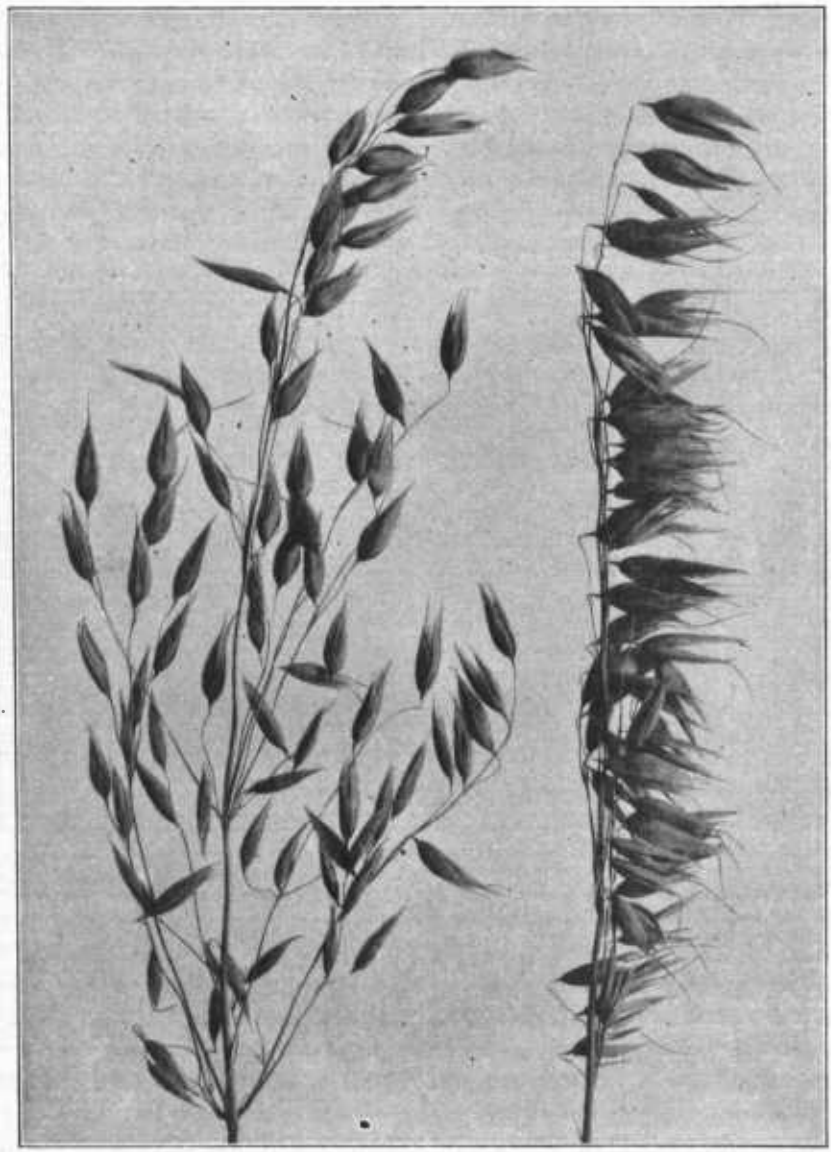

FIG. 11.—Two types of oat heads: Spreading, or panicled, oats (on the left) and side, or horse-mane, oats (on the right).

and varieties which may have been common in some sections ten or fifteen years ago have now almost entirely disappeared from cultivation.

No definite lines can be drawn between the belts where certain varieties or types of oats succeed and others fail. Local conditions of soil, climate, altitude, and latitude materially influence the adaptation of varieties, and there is naturally considerable overlapping along the borders of the belts. Figure 12 shows approximately the areas to which certain types or varieties are adapted. The unshaded portion, comprising the entire northern portion of the United States, with a large part of the Rocky Mountain section, is generally suitable for the production of the large-grained, medium to late maturing varieties. Those which are usually grown are white in color, as Clydesdale, Big Four, Swedish Select, Lincoln, White Russian, and Tartarian. The two varieties last mentioned are side oats, a class which

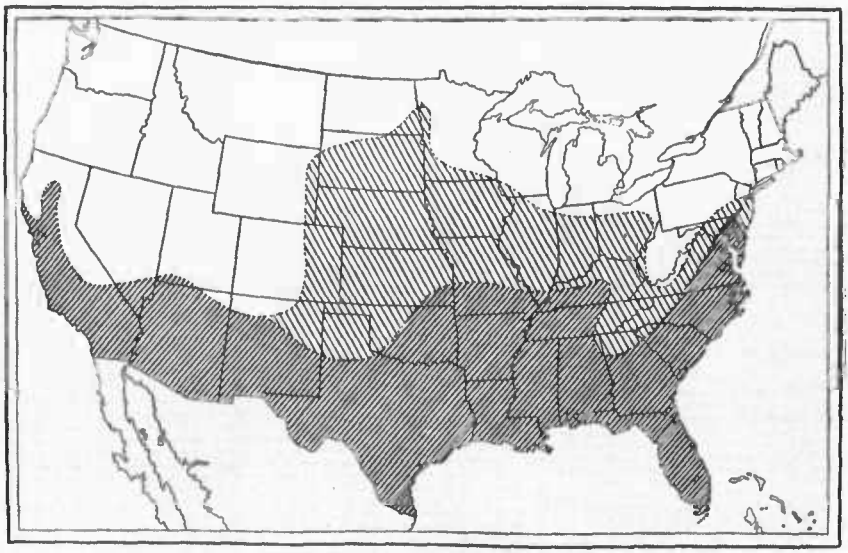

FIG. 12.—Map of the United States, showing approximately the areas to which certain types of oats are adapted. In the unshaded portion rather late maturing, large-grained white oats are usually best; in the lightly shaded portion early, small-grained, yellow varieties are most important; while in the heavily shaded portion brownish-red or gray varieties, which in the warmer sections are sown in the fall, are most certain to succeed.

can be grown with profit only in this section. Black or yellow varieties are occasionally grown, while on the dry farms of the Rocky Mountain States early oats like the Sixty-Day and the Kherson are frequently sown. In the region shown as the lightly shaded portion of the map, largely confined to the Missouri and central Mississippi valleys and including practically all the Great Plains region, small-grained, early, yellow varieties, like the Sixty-Day and the Kherson, are best adapted. In the southern portion of this area two early varieties which are also adapted to the southern belt, the Burt, with light-brown grains, and the Red Rustproof, which is reddish-brown in color, succeed equally as well as the Sixty-Day and the Kherson,

while in the northern portion the later, white varieties adapted to the northern belt succeed in favorable seasons. In the entire southern portion of the country, which is heavily shaded on the map, the varieties which do best when sown in the spring are the Burt and the Red Rustproof. For fall seeding the Winter Turf, a hardy, medium-sized, gray oat, and in the warmer portions of the area the Red Rustproof are the varieties which are usually used.

The best basis for recommendations as to varieties for any given section is furnished by the variety trials conducted by the agricultural experiment stations, but these can not always be taken as a guide, as varieties which do well on the type of soil represented by the station may not succeed on some other type of soil in the same State. The varieties mentioned in the following paragraphs are those which have done particularly well in the station tests or which are in common cultivation in the particular section under discussion. Other varieties might generally be mentioned which under some conditions would succeed as well as or better than those which are discussed.

NEW ENGLAND AND NEW YORK.

The type of oats commonly grown in the Northeastern States is medium to late in maturing, with large, usually rather short and plump, white grain. The varieties commonly offered by seedsmen in this section are Clydesdale, Probsteier, Welcome, Canadian Cluster, American Banner, White Tartar, and Swedish Select, or, as it is incorrectly called, Washington or Swedish. Little work in variety testing has been reported by the experiment stations in this section.

PENNSYLVANIA, NEW JERSEY, DELAWARE, AND MARYLAND.

The conditions in the States of this group are so diverse that general recommendations as to varieties are difficult to make. Most of the varieties mentioned in the previous paragraph are quite commonly offered by Pennsylvania seedsmen and are adapted to the higher portions of that State and of New Jersey and Maryland. The leading varieties of oats at the Pennsylvania station are Joanette, Big Four, Japan, and Lincoln. The Sixty-Day, an early variety, has given excellent results in the last few years. The hardier winter oats, such as Winter Turf and Red Rustproof, can usually be grown with success in the lower portion of Maryland. Where a spring oat is desired for this section or for Delaware best results can usually be obtained from early-maturing kinds, such as Sixty-Day, Burt, or Red Rustproof.

SOUTH ATLANTIC AND GULF STATES.

Wherever climatic conditions will permit in the South Atlantic and Gulf States it is advisable to grow winter oats of the Winter Turf or Red Rustproof types. Winter Turf is the hardier of the two

and is rather better for pasture and for hay production, but where good yields of grain are desired Red Rustproof should be grown. Where the growing of winter oats is uncertain, as in the mountainous sections, or where, for other reasons, it is desired to sow oats in the spring, Red Rustproof, Culberson, and Burt are commonly grown. In some sections, particularly in portions of Tennessee, the Burt, or as it is also known, the Ninety-Day or May, is most popular. At the Virginia station the Silvermine is the leading variety in recent tests, while the Culberson is the winter oat usually grown. At the Tennessee station Kherson and Sixty-Day have given good yields from spring seeding. The Appler is a popular variety of the Red Rustproof type in some sections, particularly in Georgia and Alabama.

WEST VIRGINIA AND KENTUCKY.

In West Virginia and eastern Kentucky, on account of the high altitude, varieties of oats are grown that are commonly found farther north. The best varieties in a test at the West Virginia station were White Russian, Big Four, American Banner, and Silvermine. At the Kentucky station Badger Queen, American Triumph, and American Beauty were among the leading kinds. In central and western Kentucky early oats like Burt, Sixty-Day, Red Rustproof, and Kherson should do well, while Winter Turf is grown as a winter oat in some sections and is worthy of more extended trial.

MICHIGAN, WISCONSIN, MINNESOTA, AND THE DAKOTAS.

As conditions are more favorable for the production of oats in the States along the northern border, a wider range of varieties can be grown with success than in any other section. In unfavorable seasons, particularly in southern Wisconsin and Minnesota and in South Dakota, early varieties like Sixty-Day and Kherson will make the best yields, but in more favorable years the larger, later ones will do best. In Wisconsin, Minnesota, and North Dakota and in the Rocky Mountain States, side oats like White Russian and Tartarian reach their best development, but even here they usually do not yield as well as some of the varieties of the open-headed type. The results of variety trials at the Michigan station have not been published in recent years, but in general the varieties that do well in Wisconsin and Minnesota succeed in Michigan. Sixty-Day, Kherson, Silvermine, and American Banner are the leading varieties at the Wisconsin station in recent years. Swedish Select, the most popular oat in Wisconsin, has given the highest yield at this station for a longer period. At the Minnesota station American Banner, Early Gothland, Kherson, and Sixty-Day have yielded best. The high place held by the Sixty-Day and the Kherson oats in the tests at these two stations is largely due to the fact that at least two of the

years covered by these tests have been extremely unfavorable to the production of late oats.

At Fargo, N. Dak., in the Red River Valley, Sixty-Day, Tartarian, Abundance, Siberian, and Lincoln have been the leading varieties, while at Edgeley the best yields have been harvested from Abundance, Siberian, Sixty-Day, and Silvermine. Early Mountain, Kherson, Tartarian, and Banner have been the best of the well-known varieties at Dickinson, though several kinds recently imported from Europe have done well. At Williston the Silvermine, Siberian, and Probsteier have made the best showing. At the South Dakota stations Kherson, Swedish Select, and Sixty-Day have been the highest yielding varieties.

OHIO, INDIANA, ILLINOIS, IOWA, AND NEBRASKA.

At the Ohio station Siberian, Sixty-Day, Improved American, and Joanette were the leading varieties in a recent test. Big Four and Silvermine have also given good results. At the Indiana station the leading varieties are Great Dakota and Silvermine. Early oats usually yield best in Illinois, Iowa, and Nebraska, as late ones are likely to be severely injured by hot weather when the grain is filling. At these stations Sixty-Day and Kherson are among the leading kinds. Burt and Red Rustproof have also done well in Nebraska, while Silvermine and Swedish Select have been good varieties in the Iowa tests, and Siberian is one of the best at the Illinois station. Silvermine, Big Four, Swedish Select, and other large, rather late, white oats will give good yields in the northern parts of these States in favorable years, but in unfavorable ones Sixty-Day and Kherson will produce more grain. Early Champion is an early oat which is extensively grown, while Lincoln, Clydesdale, and Green Russian are also quite popular.

MISSOURI, KANSAS, OKLAHOMA, AND ARKANSAS.

Most of the oats grown in these States are of the Red Rustproof type. At the Kansas station Sixty-Day and Kherson have given equally as good results as Red Rustproof; at the Oklahoma station Red Rustproof and Kherson have been the leading varieties. Variety trials of oats have not been reported recently from the Missouri and Arkansas stations, but it is probable that the 3 varieties mentioned will give as good results in those States as in Kansas and Oklahoma. Winter oats can be grown with a fair degree of success in some portions of Arkansas and Oklahoma.

ROCKY MOUNTAIN STATES.

In the Rocky Mountain States, where oats are grown under irrigation, the large, late, white varieties give the largest yields and are

the most popular. On the dry farms early kinds, like Sixty-Day and Kherson, usually make the best showing. The Swedish Select is also a good dry-farm oat. At the Montana station, under irrigation, Progress, Clydesdale, Big Four, and Improved American are among the leading varieties. Swedish Select and White Russian are also grown on the irrigated farms of Montana, Wyoming, and Idaho. In Colorado Kherson, Sixty-Day, and a variety developed by the experiment station and known as Colorado No. 37 are popular, particularly on the dry farms. The varieties grown on the irrigated farms are about the same as those grown in Montana and Wyoming.

PACIFIC STATES.

The conditions in western Washington and Oregon and in the irrigated sections of these States and of Idaho are very favorable to the growth of oats. The highest yields are usually harvested from large, white oats like Big Four, Improved American, and Swedish Select. Side oats are also rather popular. In the dry-land sections there is no better variety than Sixty-Day. Where conditions are favorable for winter oats the varieties known as Black Russian and Gray Winter (Winter Turf) are grown. In California the Red Rustproof, or, as it is commonly known, Red, or Common California, is usually grown.

IMPROVEMENT OF THE CROP.[a]

EFFECT OF THE SOURCE OF SEED ON YIELD.

Thorough cleaning of the seed grain and sowing only that which is large and plump has already been recommended. The procuring of seed oats from distant localities more favorable to the production of the crop is often advocated, particularly in sections where the grain is of poor quality, or following partial failures. If there is a reasonable certainty that the seed thus obtained is of a variety adapted to the region where it is to be grown, the purchase of new seed from a distance can be made with considerable promise of gain. If, however, the variety is unknown or is likely to be one not well adapted to local conditions, the change of seed should be made with caution. For instance, the large, late varieties of oats commonly grown in Canada and in the irrigated districts are not likely to give any better yields when sown in Iowa or Illinois than are the varieties commonly grown in those States, even though the seed of the latter is of poor quality. The Kansas station found that by grading the seed each year and sowing only plump, sound grain, the yield could be increased over that from seed procured from other sections. At the Virginia

[a] A more complete discussion of this subject is contained in Circular 30, Bureau of Plant Industry, U. S. Dept. of Agriculture, entitled "The Improvement of the Oat Crop."

station, in a very unfavorable year, 10 per cent more grain was produced from home-grown seed than from that of the same varieties brought from a distance.

IMPORTATION OF SEED OATS.

Most of our best varieties of oats have been brought from Europe, where much more attention has been given to the improvement of the crop than in this country. The European varieties do best here, however, when grown under conditions similar to those in the regions where they were developed. A good variety of oats from Sweden can be expected to give much better results in Minnesota or Wisconsin than in Illinois or Iowa, because the conditions are more nearly the same, while one from central or southern Russia is most likely to succeed in our own Central States. Thus, the Kherson and the Sixty-Day from southern Russia are proving of great value in Nebraska, Iowa, and Illinois, while the varieties from Sweden, Germany, and northern Russia are doing best in Wisconsin, Minnesota, and the other Northern States. The importation of oats from foreign countries, though it is an interesting and valuable part of the work of the Department of Agriculture and the experiment stations, can hardly be undertaken by the farmer. A comparatively small portion of the varieties imported prove to be marked successes.

FIELD SELECTION OF SEED.

In addition to the mechanical selection of the large, heavy seed by the fanning mill or similar means the farmer can increase the yield and the quality of the oats he grows by selecting the best heads or the best plants in the field. These can be thrashed together and sown in a seed plat separate from the main crop, or the individual heads can be planted in separate rows and used for the development of pedigreed strains. While good results can be obtained from growing this selected seed in bulk, as first mentioned, the most reliable method of improving the quality and yield of the oat crop is by the selecting and testing of strains developed from individual plants or heads. Those which are inferior should be discarded from the first year's test, and the really superior ones increased and again selected. The hybridization of oats is a difficult process, and the selection of the hybrids and their fixation as pure types is a problem which should be left to the professional plant breeder. Much can be done in the improvement of the crop through the selection of the best individual plants, however, to increase the yield or the proportion of kernel to hull. This proportion is an important consideration, as it so materially affects both the feeding and the milling values of the grain.

DISEASES AFFECTING OATS.

THE SMUTS.

The most common diseases of oats are smut and rust. There are two smuts of oats, both of which destroy the grain. In the common, or loose smut, all the parts of the flower or grain, including the chaff, are replaced by a black, powdery mass of spores. Heads of oats affected by this smut are shown in figure 13. In the less common form, the covered smut, the grain is destroyed but the smut spores remain inclosed in the glumes. The manner of infection and growth is the same with both kinds of smut, as the smut spores enter the growing parts of the young plant at germination and grow with it until they develop in the head, turning all or a part of the grains into masses of spores. Both the loose and covered smuts of oats are easily destroyed by the formalin treatment described on page 17. The loss from oat smut is considerable, being variously estimated at from 2 to 10 per cent of the crop. Unless definite counts of smutted heads are made the injury is usually underestimated, as the smutted heads usually appear earlier and are shorter than those which bear grain, so that many are not noticed in a casual inspection of a field. At a conservative estimate of 3 per cent the annual loss from this disease is about 27,000,000 bushels of oats, which, at 40 cents a bushel, are worth nearly $11,000,000.

THE RUSTS.

The rusts are easily recognized by the appearance of irregular, roughened areas on the leaves and stems, which at maturity discharge large numbers of red or black spores. The most common rust of oats is the crown rust, usually known as the red or leaf rust, though the stem rust also commonly occurs on this grain. The crown rust does not injure the crop as seriously as the stem rust, which, when it occurs, makes its appearance a few days later than the crown rust, and is likely to do serious damage. These rusts take the food from the stems and leaves of the oat plant that would naturally go to the development of the grain, and as a result the grain is light and shriveled. No accurate estimate of the damage done by the rusts can be made, but it is probably even larger than that done by the smuts. There are no known means of combating the rusts when they occur. The damage may be somewhat reduced, however, by early planting or by the planting of varieties which mature before the black rust develops and by planting on well-drained land, as moisture is essential to the development of rust. The Red Rustproof oat is quite resistant to rust in the South, where the disease is usually prevalent, but is much less resistant in other sections. Drilled oats are less liable to injury from rust than those sown broadcast, as light

and air can penetrate between the drill rows. Rank growth resulting from rich soil, excess of nitrogenous fertilizers, or abundant moisture also favors the development of rust.

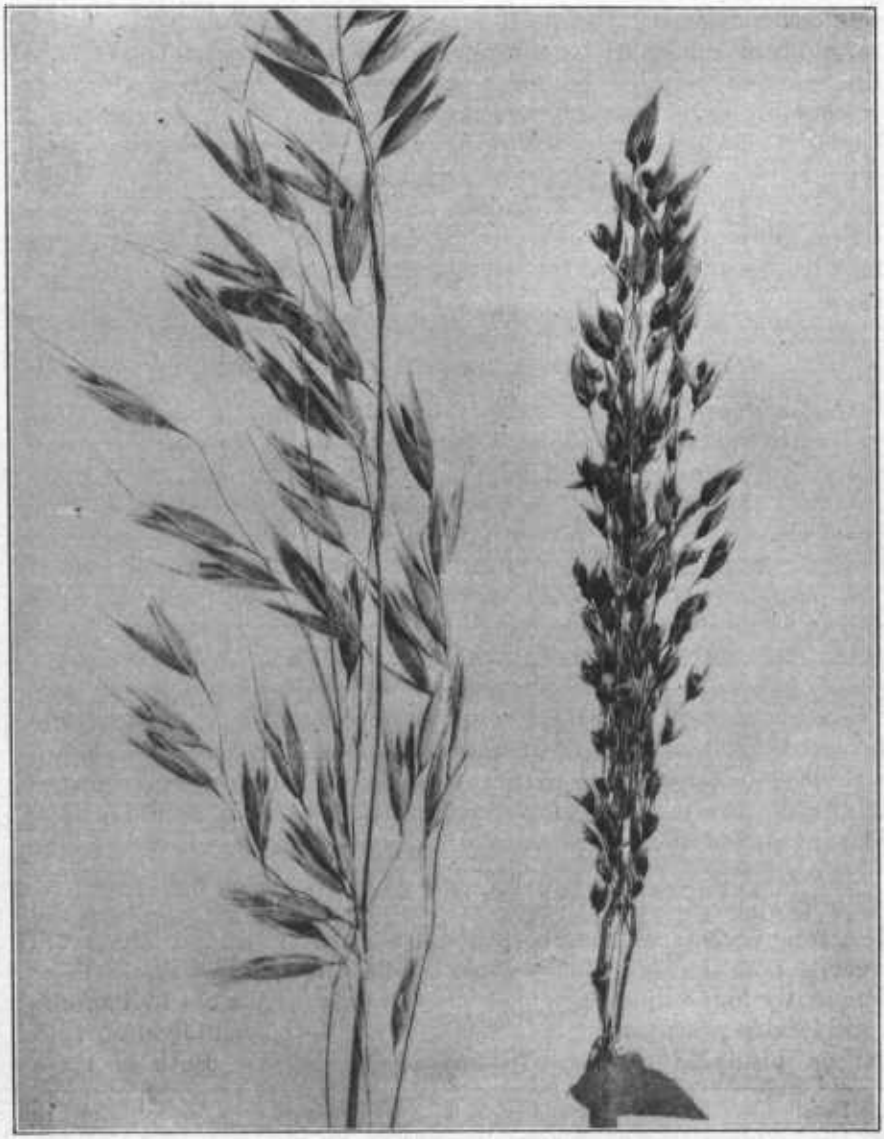

FIG. 13.—Smut of oats: Smutted head (on the right) and head not affected by smut (on the left).

OTHER DISEASES.

Several other diseases sometimes damage the oat crop, but none of them is so common or causes so much damage as do the rusts and smuts. In very wet seasons mildew occurs where the growth is rank

and the oats have lodged from storms: Cold, wet weather early in the season may cause the leaves of the oats to turn yellow, but usually the plants recover when conditions for growth become more favorable. The injury may become serious if the unfavorable weather continues for some time. Spikelet blight, a disease which is readily recognizable by the presence of white, barren spikelets as the heads develop, is sometimes quite prevalent, but the real nature of the trouble is not well understood. Blade blight, supposedly a bacterial disease causing yellowing of the oat leaves, is believed by some to be associated with spikelet blight. It has recently been described by Prof. Thomas F. Manns, of the Ohio station. No preventive is known for either of these blights. Ergot, which is often common on rye and some of the wild grasses, occurs rarely on oats.

INSECTS INJURIOUS TO OATS.

INSECTS ATTACKING THE GROWING PLANT.

Oats are probably less subject to insect injury than any other important small-grain crop. The chinch bug, the spring grain-aphis [a] or so-called "green bug," and the army worm are perhaps the most destructive, but severe damage from the attacks of even these insects occurs at rather infrequent intervals. Oats are much less frequently injured by chinch bugs than wheat, rye, or barley. The best preventive measure is the burning of rubbish along fences and in fields in which the bugs may hibernate. The spring grain-aphis frequently appears on young grain plants of all kinds, but causes noticeable damage only in an unusually cold, wet spring, preceded by an unusually mild winter, when conditions are especially favorable to its development and at the same time unfavorable to the rapid increase of its natural enemies. As it frequently makes its appearance in small areas, from which it spreads over the field, plowing under these areas as soon as noticed is sometimes effective.

INSECTS ATTACKING THE STORED GRAIN.

Among insects commonly attacking stored grain are the grain weevils and the Angoumois grain moth. They are usually more frequently found in other cereals than in oats, as the oat hull affords considerable protection. Injury can be checked by fumigation with carbon bisulphid [b] or with hydrocyanic-acid gas.[c] Both of these

[a] Detailed descriptions of these insects, with methods of control, are contained in the following circulars of the Bureau of Entomology, U. S. Dept. of Agriculture: Circular 93, "The Spring Grain-Aphis," and Circular 113, "The Chinch Bug."

[b] Farmers' Bulletin 145, U. S. Dept. of Agriculture, 1902, entitled "Carbon Bisulphid as an Insecticide," gives complete directions for the use of this gas in fumigating grain. It may be obtained free on application to the Secretary of Agriculture.

[c] Circular 112, Bureau of Entomology, which contains directions for fumigating stored cereals with hydrocyanic-acid gas, may be obtained without cost on application to the Secretary of Agriculture.

are dangerous poisons and must be handled with extreme caution. Tight bins from which the gases can not escape are necessary. Carbon bisulphid is more commonly used than hydrocyanic-acid gas for fumigating grain. The vapor given off by the bisulphid is highly inflammable, hence no fire, lighted cigars, etc., should be brought near it when it is being used. The gas produces unpleasant effects when inhaled, so that care should be taken not to breathe much of it. It is heavier than air and sinks to the bottom of the bin when the bisulphid is placed in vessels on top of the grain or poured on it. From 1 to 2 pounds of the bisulphid is sufficient to fumigate 1 ton of grain or 1,000 cubic feet of bin. Open bins will require a still larger quantity.

SUMMARY.

Oats were probably first cultivated in eastern Europe and western Asia, where the original wild form is supposed to have existed.

The oat belongs to the grass family and is known botanically as *Avena sativa*.

This crop grows best on soils with good water-holding capacity, as it requires a great deal of moisture. When grown for grain, phosphorus is usually the most important fertilizing element which can be added. Very rich soils, especially if deficient in phosphorus, cause rank growth, with lodging as a result. When grown for hay or forage nitrogenous fertilizers may be used.

Oats are usually grown in the rotation after a cultivated crop, and are used as a nurse crop for grasses or clover. They are sometimes grown in combination with other crops. When grown with barley large yields of grain for feeding can be obtained, while with Canada field peas or vetch excellent forage is produced.

Oats do best on a rather loose, well-prepared seed bed. The common method of sowing the grain broadcast on cornstalk land without preparation and covering it with the disk harrow is careless and uncertain. Thorough preparation of the seed bed is strongly advised.

Only plump, heavy oats should be used for seed. The seed should be treated for smut before sowing. The formalin treatment is effective and is easily applied.

Drilling usually gives better germination, a more nearly uniform stand, and higher yields than broadcast seeding. The rate of seeding varies with the locality and other factors. In the upper Mississippi Valley 2½ to 3 bushels are usually sown to the acre. Oats should be sown as early in the spring as the ground can be worked.

In dry-farming sections harrowing drilled oats while the plants are small increases the yield. Spraying with a solution of iron sulphate to kill weeds is recommended by some of the agricultural experiment stations. The largest yield of oats per inch of water applied is usually obtained in the irrigated sections by the use of 15 to 20 inches.

Oats are usually harvested with the grain binder, set up in shocks of 10 or more bundles, and allowed to cure for ten days or two weeks. They are then stacked or hauled direct to the thrasher and thrashed. In the humid regions a better quality of grain is usually obtained at slightly increased cost from stack thrashing than from shock thrashing. Where there is little rainfall there is no advantage in stacking. The mixing of grain in the separator and the introduction of weeds from neighboring farms by the thrashing outfit should be carefully avoided. The thrashing machine should be adjusted to remove all the grain from the straw and to remove the trash from the grain. The grain should be stored in clean, dry bins, well protected from the weather, and kept free from vermin.

The average yields of oats vary from 15 to 25 bushels in the Southern States, from 25 to 40 bushels in the Northern States, and from 35 to 45 bushels in the Rocky Mountain and Pacific States. Yields of 100 to 150 bushels to the acre are sometimes produced in the Northwestern States, particularly in the irrigated regions.

The cost of production is estimated at from 20 to 25 cents a bushel. The cost per bushel of very low yields is considerably greater.

Many varieties of oats are grown in the United States. These varieties differ in the size, color, and shape of the grain, the length of time required to attain maturity, the shape and size of the head, the yield, and in winter hardiness. The number of varieties adapted to any particular section is comparatively small. In general, reddish brown (Red Rustproof) or gray (Winter Turf) oats are adapted to the South; early oats, usually yellow in color (Sixty-Day and Kherson), to the Central States; and white, large-grained, later varieties (Swedish Select, Clydesdale, Silvermine, etc.) to the Northern States.

The improvement of the crop can be effected through the seed by grading and sowing only the large, plump grain, by bulk selection of the best plants, and by individual plant selections. The latter is the only method by which pedigreed varieties can be established. Good varieties are sometimes obtained by importation from foreign countries.

The principal diseases of oats are smut and rust. Smut may be controlled by the use of the formalin solution; good preventive measures against rust are the sowing of early varieties and sowing only on well-drained land.

The principal insect enemies of growing oats are the spring grain-aphis, the chinch bug, and the army worm. The remedies applicable to other small-grain crops apply to oats. Grain weevils and moths do rather less injury to oats than to other grains, because the hull of oats serves as a protection; fumigation with carbon bisulphid or hydrocyanic-acid gas is recommended for these insects.

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